J. Appl. Hort., 3(1):13-16, January-June, 2001

Interactions among rooting substrate, phenological stage of cuttings and auxin concentration on the rooting of *Cotinus obovatus*

Geoffrey C. Denny and Michael A. Arnold

Department of Horticultural Sciences, Texas A&M University, Mail Stop 2133, College Station, TX 77843-2133, USA.

Abstract

A study was conducted to determine the effects of substrate, phenological stage of cutting, and auxin concentration on the rooting of Texas smoke tree (*Cotinus obovatus* Raf.). Cuttings from new lush growing tips (softwood), partially matured tissues (semi-mature wood) and mature woody fully lignified cuttings from the previous season's growth (mature wood) were treated with either a 0 , 5000, 10000 or 15000 mg L^{-1} (ppm) potassium salt of indolebutyric acid (K-IBA) and placed in either 50% peat : 50% perlite or 100% perlite rooting substrates. Cuttings were placed under an intermittent mist system in a greenhouse for 8 weeks. Softwood cuttings rooted in both substrates, but the 50% peat : 50% perlite substrate produced better quality rooted cuttings. Softwood cuttings peaked at 8,000 to 10,000 mg L^{-1} (ppm) K-IBA. Semi-mature wood and previous season's growth cuttings rooted only in the 100% perlite substrate. In 100% perlite substrate, the optimal concentration for semi-mature wood cuttings was approximately 12000 mg L^{-1} (ppm) K-IBA, while mature wood rooting was maximized at 15000 mg L^{-1} (ppm) K-IBA or more.

Key words: Texas smoke tree, American smoke tree, Chittamwood, *Cotinus obovatus* Raf., propagation, adventitious rooting, growth regulators, rooting sustrate

Introduction

The rapidly increasing human population in Texas and a static or decreasing water supply necessitate wise use of available water (Welsh *et al.*, 1991). Similar conditions exist in other semi-arid regions with growing populations. This necessitates water conservation, and one of the easier ways for homeowners and businesses to conserve water is by xeriscaping with drought tolerant plants (Welsh *et al.*, 1991). There is an increasing demand from consumers for low maintenance, drought tolerant plants that are attractive and durable (Wasowski and Wasowski, 1997). There are numerous species that meet these criteria and have potential in the landscape trade (Arnold, 1999, Wasowski and Wasowski, 1997). However, many are not readily available at nurseries and garden centers (Goyne and Arnold, 1996). Due to the limited amount of data that exists about the cultural requirements of native species, and with the increasing demand, there is a growing need for research in this area.

Cotinus obovatus is a large shrub or small tree, growing from 4.6 m to 10.7 m (15 ft. to 35 ft.) in height (Arnold, 1999, Simpson, 1988, Vines, 1960). The common names, Texas smoke tree and American smoke tree, refer to the tree's flowers which form purple/pink clouds of filamentous peduncles in mid-spring (Harrar and Harrar, 1946). The leaves are deciduous, simple, obovate, 3.8 cm to 15.0 cm (1½ in. to 6 in.) long and 5.0 cm to 8.9 cm (2 in. to 3½ in.) wide, and when the leaves emerge in the spring they are colored both pink and lime (Vines, 1960, Wasowski and Wasowski, 1997). They also show a wide range of fall color, from yellow and orange to bright scarlet (Arnold, 1999, Vines, 1960). The twigs change from green to reddish or purple colors, and eventually gray with age (Vines, 1960). *Cotinus obovatus* grows on well drained, limestone soils and is a good ornamental tree for sites meeting this description (Arnold, 1999, Wasowski and Wasowski, 1997). On these sites, it is often hard to grow other species (Wasowski and Wasowski, 1997). *Cotinus obovatus* has potential as a landscape plant, but vegetative propagation methods have not been fully developed (personal communication, Dr. Wayne A. Mackay, Texas Agricultural Research and Extension Center at Dallas, Dallas, TX, March 12, 1999).

Hartman *et al.* (1997) state that rooting substrates should hold enough moisture to provide sufficient water to the cuttings once mist intervals are reduced. Substrates should be "sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the roots" to ensure good rooting. Koller and Shadow (1984) report that it is critical to not let *C. obovatus* cuttings stay too wet.

Cuttings are treated with auxins to increase rooting percentages, to shorten the rooting period, and to give more uniform rooting (Hartmann *et al.*, 1997). In general, the more phenologically mature the tissue, the higher the optimum auxin concentration required to induce rooting (Hartmannn *et al.*, 1997). At high auxin concentrations, there is the possibility of toxicity, which can lead to poor survival in rooted cuttings (Hartmann *et al.*, 1997). Koller and Shadow (1984) recommend Hormodin Number 3 (8000 mg L^{-1} (ppm) IBA) for use on softwood cuttings of *C. obovatus*.

Limited information currently available on vegetative propagation of *C. obovatus* suggests the need for investigation of the effects of different substrates, physiological stage of the cutting, and auxin concentration. Therefore, the objective of this study was to compare these factors on the development of adventitious roots from vegetative shoot tips of *C. obovatus*.

Materials and methods

Cuttings at three phenological states (softwood, semi-mature wood, and mature wood) were collected at the Texas Agricultural Research and Extension Center at Dallas. The softwood was defined as new succulent, growing, non-lignified shoot tip; semi-mature wood was tissue that was beginning to mature, slow growth, and undergo lignification; and mature wood was cutting selected such that the basal portion was lignified previous season's growth. The cuttings were transported in sealed plastic bags by truck and stored in a 4°C cooler until treated. Cuttings were trimmed to 12.5 cm to 15.0 cm with an approximate 45° angle at the base of the cutting immediately beneath a node. The lower four nodes were stripped of leaves. The cuttings were submerged for approximately 7 sec. in a 50 mg L^{-1} bromine solution to prevent algal, fungal, and bacterial growth. Afterward, the bottom 5.0 cm of the cuttings were treated with different concentrations of K-IBA: 0 mg L^{-1}, 5000 mg L^{-1} (ppm), 10,000 mg L^{-1} (ppm), or 15,000 mg L^{-1} (ppm). A control group of cuttings with no treatment (either K-IBA or bromine) was also included. Fifteen cuttings, at each concentration level were placed into 50 cell (5.0 cm x 6.0 cm) plug sheets (Landmark Plastic Corporation, Akron, Ohio) filled to level with the 1 part sphagnum peat (Sun Gro Horticulture, Pine Bluff, Arkansas):1 part coarse perlite (Strong-Lite® Products Corp., Pine Bluff, Arkansas) (by volume) rooting mix with 1 cutting per cell and five cuttings per block. The cuttings were inserted by pushing them directly into the substrate to a depth of 6.0 cm. Fifteen cuttings were identically placed into 50 cell plug sheets filled with 100% coarse perlite. Sheets containing a given substrate were randomly intermixed within a block.

These two substrates were chosen because the 1 part sphagnum peat : 1 part coarse perlite (by volume) is a conventional rooting substrate with high water holding capacity, which is based on the Cornell Peat-Lite mixes (Hartmann *et al.*, 1997). The second substrate is 100% coarse perlite, a substrate that provides good drainage and aeration (Hartmann *et al.*, 1997).

Cuttings were placed immediately in a greenhouse under an intermittent mist system (6 sec. every 8 min., dawn to dusk) using reverse osmosis treated water for eight weeks. The treatments were monitored weekly to determine if rooting had occurred. The cuttings were harvested after eight weeks because there was significant rooting in most treatments and non-rooting treatments were beginning to deteriorate (defoliation, development of necrotic tissues on the stems). At harvest, the number of cuttings rooted out of 5 in each block and the mean number of roots per cutting were determined. The mean of the shortest and the longest roots per cutting was determined and a mean for each replication generated. Fresh mass of the roots per replication was measured immediately after harvest. Root samples were dried in an oven (70°C for 6 days) and the dry root mass was measured.

The statistical design in the greenhouse was a randomized complete block (2 substrate x 3 cutting types x 5 K-IBA treatments x 3 blocks with 5 cutting replications per block). In the initial analysis the 0 mg L^{-1} (ppm) ± bromine treatments were compared to determine the effects of bromine utilization. After pooling the 0 mg L^{-1} (ppm) treatments, analysis of variance were conducted for the remaining factors (SAS Institute, 1988). Means, standard errors and step-wise polynomial regression equations were generated for significant effects. Only interactions or main effects not involved in significant (p>0.05) higher order interactions are presented.

Results and discusssion

Controls did not differ significantly (paired t-test, p>0.05), therefore, 0 mg L^{-1} (ppm) ± bromine were pooled to evaluate the 0 mg L^{-1} K-IBA treatment effects in subsequent analysis. Third order interactions among substrate type, cutting type and auxin concentration were significant ($p \leq 0.05$) for all rooting measures. Hence, lower order interaction and main effects are not presented. Data indicated similar results for both dry and fresh mass, therefore only dry mass data are presented.

Softwood cuttings were the only type of cutting, that had significant rooting in the 50% peat : 50% perlite (by volume) substrate, whereas semi-mature wood and mature wood did not root (Table 1). This may have been due to the higher water holding capacity of the substrate compared to 100% perlite. The younger, suppler, tissue may have benefited from the extra moisture, but the added moisture retention may have been excessive for the more mature tissues. This is in agreement with Koller and Shadow (1984), who suggested for not keeping *C. obovatus* cuttings too wet during propagation. Also, Hartmann *et al.* (1997) suggest that excessive water in the rooting substrate is detrimental to root formation. Goyne (1998) reported rooting in low percentages using a 3 parts fine screened pine bark : 1 part builders sand (by volume).

Softwood cuttings in both substrates had the highest number of rooted cuttings at approximately an 8,000 to 10,000 mg L^{-1} K-IBA concentration (Table 1). This is in agreement with Koller and Shadow's (1984) recommendation of 8,000 mg L^{-1} IBA with softwood cuttings. The softwood, 50% peat : 50% perlite treatment had significantly higher numbers of roots per cutting, longer roots, and greater root dry masses (Table 1) than the softwood, 100% perlite treatment, when auxin was applied. This may be due in part to the more damaging nature of the 100% perlite substrate to the softer tissue during the insertion process and increased moisture content in the 50% peat : 50% perlite substrate over that of perlite alone. The addition of peat moss to coarser textured substrate components can significantly increase the water holding capacity of the resultant substrate over that of a substrate composed entirely of the coarse textured component (Goyne, 1998). The softwood, 50% peat : 50% perlite treatment had significantly longer roots than the other treatments and a larger root dry mass. This may again be the result of the increased root available moisture in the peat containing substrate.

Semi-mature wood in the 100% perlite treatment had the maximum number of rooted cuttings per five (Table 1), more roots per cutting , and greater root dry masses at concentrations of approximately 12,000 to 15,000 mg L^{-1} K-IBA. The same substrate and cutting type had peak root length at lower concentrations, approximately 8,000 to 10,000 mg L^{-1} K-IBA.

Table 1. Rooting of softwood, semi-mature, and mature wood cuttings of *Cotinus obovatus* in 100% perlite or 50% peat and 50% perlite substrates under intermittent mist after basal treatment with K-IBA at 0, 5000, 10000, or 15000 mg·L^{-1}

Cutting maturity	Substrate	K-IBA (mg·L^{-1})	Rooted cuttings (# per 5)	Roots/ cutting (Number)	Root length (mm)	Root dry mass[z] (mg)
Softwood	Perlite	0	0.3	0.7	0.7	0
		5000	3.3	5.3	4.7	4
		10000	1.7	2.3	2.8	1
		15000	2.7	9.8	8.0	8
Semi-mature	Perlite	0	0.2	0.3	1.3	0
		5000	1.7	2.9	8.1	2
		10000	3.3	20.3	8.4	23
		15000	0.3	10.8	6.5	12
Mature	Perlite	0	0	0.0	0.0	0
		5000	0.7	2.0	7.8	3
		10000	0.7	2.9	7.8	3
		15000	3.3	13.5	11.9	16
Softwood	Peat/perlite	0	0.5	0.7	10.6	1
		5000	0.2	9.2	40.8	16
		10000	3.3	27.9	63.1	35
		15000	2.0	20.1	36.8	26
Semi-mature	Peat/perlite	0	0	0.0	0.0	0
		5000	0	0.0	0.0	0
		10000	0.3	0.9	8.4	1
		15000	0.3	0.1	6.5	0
Mature	Peat/perlite	0	0	0.0	0.0	0
		5000	0	0.0	0.0	0
		10000	0	0.0	0.0	0
		15000	0	0.0	0.0	0
ANOVA Effects						
Cutting maturity			***z	**	***	**
Substrate			***	NS	***	NS
Cutting maturity x substrate			***	***	***	***
K-IBA			***	***	***	***
Cutting maturity x K-IBA			***	NS	*	NS
Substrate x K-IBA			***	NS	NS	NS
Cutting maturity x substrate x K-IBA			***	**	**	**

[y] Root mass of 5 cuttings

[z]Indicates ***, **, *, or NS is a statistically significant at alpha = 0.1%, 1%, 5%, or not

Peak rooting of the mature wood in 100% perlite occurred at 15,000 mg L^{-1} in terms of number of rooted cuttings per five, number of roots per cutting, root length and dry mass (Table 1). However, an optimal concentration was not determined as concentrations in excess of 15,000 ppm were not tested. Results for both the semi-mature wood and mature wood treatments follow a conventional trend for adventitious rooting of stem cuttings, that is more mature tissues normally require a higher auxin concentration to root in similar numbers as less physiologically mature tissues.

Propagation of softwood cuttings can be achieved in either substrate with a concentration of 8,000 mg L^{-1} K-IBA, however, the 50% peat : 50% perlite substrate produced higher quality rooted cuttings. When using 100% perlite, holes should be made in the substrate prior to inserting the cutting to prevent damaging the tissue and possibly improve rooted cutting quality.

When propagating semi-mature wood or mature wood cuttings, the better-drained substrate is critical. To obtain peak rooting, a K-IBA solution of approximately 12,000 mg L^{-1} should be used for semi-mature wood and at least a 15,000 mg L^{-1} K-IBA solution for mature wood cuttings in 100% perlite substrate.

Survival studies were not performed on any of the rooted material due to the destructive nature of the rooting measurements collected, therefore possible detrimental effects of the higher concentrations of K-IBA could not be assessed. Additional examination and experimentation in this area would be beneficial. A need exists for further studies to determine the effects of possible mechanical damage during cutting insertion, as well as the utilization of other forms of rooting containers. Stock plants were growing in landscape settings, with no additional fertility applied. The physiological conditions of stock plants have been shown to impact rooted cutting performance (Moe and Andersen, 1988; Rowe *et al.*, 1996), hence studies with better tended stock plants might yield higher quality rooted cuttings.

This paper provides valuable insights to the successful cutting propagation of *Cotinus obovatus*, a highly desirable landscape tree for mesic and semi-arid landscapes. Optimal rooting concentrations of K-IBA are identified for cuttings treated at a range of developmental stages. In addition, the critical nature of substrate selection is illustrated. Semi-mature wood and mature wood cuttings must have a more porous substrate than softwood cuttings to obtain successful rooting in *C. obovatus*.

References

Arnold, M.A. 1999. Landscape Plants for Texas and Environs. Stipes Publ. L.L.C., Champaign, IL. p. 596.

Dirr, M.A. 1998. Manual of Woody Landscape Plants, 5th ed. Stipes Publ. L.L.C., Champaign, IL. p. 1187.

Goyne, M.W. 1998. Effects of Alternative Container Media Components on the Growth of Selected Under-Utilized Small Ornamental Trees. M.S. Thesis, Texas A&M Univ., College Station, TX. p. 95.

Goyne, M.W. and M.A. Arnold, 1996. Improving Availability of Under-Utilized Small Trees for Texas. Proceedings of the 9th Metropolitan Tree Improvement Alliance Conference. http://www.hcs.ohio-state.edu/METRIA/arnold/arnold.htm.

Harrar, E.S. and J.G. Harrar, 1946. Guide to Southern Trees. Whittlesey House, New York, NY. p. 712.

Hartman, H.T., D.E. Kester, F.T. Davies, Jr. and R.L. Geneve, 1997. Plant Propagation: Principles and Practices, 6th ed. Prentice Hall, Upper Saddle River, NJ. p. 770.

Koller, G.L. and D.O. Shadow, 1984. In praise of the American Smoke Tree. *Anoldia,* 44(2):17-22.

Moe, R. and A.S. Andersen, 1988. Stock plant environment and subsequent adventitious rooting. *In*: Adventitious Root Formation In Cuttings (T.D. Davie, B.E. Haissig, and N. Sankhla (eds.). Dioscorides Press, Portland, OR, pp. 214-234.

Rowe, D.B., F.A. Blazich, and R.J. Weir, 1999. Mineral nutrient and carbohydrate status of loblolly pine during mist propagation as influenced by stock plant nitrogen fertility. *HortScience,* 34:1279-1285.

Table 2. Second order polynomial regression equations for Table 1

S.N.	Rooting measure	Substrate	Cutting type	Intercept	(mg/L K-IBA)1	(mg/L K-IBA)^2	R^2	P value
1	Number of cuttings	100% perlite	Softwood	2.35x10^{-1} [x]	5.10x10^{-4}	-2.49x10^{-8}	0.46	0.034
	rooted out of five			5.79x10^{-1} [y]	2.15x10^{-4}	1.00x10^{-8}		
2	Number of cuttings	100% perlite	Semi-mature wood	1.11x10^{-1}	4.67x10^{-4}	-1.78x10^{-8}	0.79	0.001
	rooted out of five			3.05x10^{-1}	1.20x10^{-4}	1.00x10^{-8}		
3	Number of cuttings	100% perlite	Mature wood	8.55x10^{-2}	-8.21x10^{-5}	1.91x10^{-8}	0.85	0.001
	rooted out of five			2.24x10^{-1}	8.81x10^{-5}	1.00x10^{-8}		
4	Number of cuttings	50% peat /	Softwood	3.27 x 10^{-1}	5.52 x 10^{-4}	-2.88 x 10^{-8}	0.56	0.011
	rooted out of five	50% perlite		4.74 x 10^{-1}	1.76 x 10^{-4}	1.00 x 10^{-8}		
5	Number of cuttings	50% peat /	Semi-mature wood	ns[z]	ns	ns	ns	ns
	rooted out of five	50% perlite			ns	ns	ns	
6	Number of cuttings	50% peat /	Mature wood	ns	ns	ns	ns	ns
	rooted out of five	50% perlite			ns	ns	ns	
7	Number of roots	100% perlite	Softwood	5.77x10^{-1}	2.66x10^{-4}	1.92x10^{-8}	0.37	0.079
	per cutting			2.05	7.62x10^{-4}	5.00x10^{-8}		
8	Number of roots	100% perlite	Semi-mature wood	-7.64x10^{-1}	2.57x10^{-3}	-1.10x10^{-7}	0.33	0.094
	per cutting			4.18	1.65x10^{-3}	1.10x10^{-7}		
9	Number of roots	100% perlite	Mature wood	2.75x10^{-1}	-4.02x10^{-4}	8.32x10^{-8}	0.64	0.002
	per cutting			1.66	6.54x10^{-4}	4.00x10^{-8}		
10	Number of roots	50% peat /	Softwood	-2.61x10^{-1}	3.75x10^{-3}	-1.52x10^{-7}	0.37	0.077
	per cutting	50% perlite			6.38	2.36x10^{-3}	1.60x10^{-7}	
11	Number of roots	50% peat /	Semi-mature wood	ns	ns	ns	ns	ns
	per cutting	50% perlite			ns	ns	ns	
12	Number of roots	50% peat /	Mature wood	ns	ns	ns	ns	ns
	per cutting	50% perlite			ns	ns	ns	
13	Root length	100% perlite	Softwood	5.77x10^{-1}	2.66x10^{-4}	1.92x10^{-8}	0.37	0.079
				2.05	7.62x10^{-4}	5.00x10^{-8}		
14	Root length	100% perlite	Semi-mature wood	1.44	1.64x10^{-3}	-8.76x10^{-8}	0.62	0.003
				1.11	4.37x10^{-4}	3.00x10^{-8}		
15	Root length	100% perlite	Mature wood	3.06x10^{-1}	1.32x10^{-3}	-3.91x10^{-8}	0.51	0.014
				2.03	8.00x10^{-4}	5.00x10^{-8}		
16	Root length	50% peat /	Softwood	10.07	1.02x10^{-2}	-5.49x10^{-7}	0.50	0.021
		50% perlite		9.34	3.47x10^{-3}	2.30x10^{-7}		
17	Root length	50% peat /	Semi-mature wood	ns	ns	ns	ns	ns
		50% perlite		ns	ns	ns		
18	Root length	50% peat /	Mature wood	ns	ns	ns	ns	ns
		50% perlite		ns	ns	ns		
19	Root Dry Mass	100% perlite	Softwood	4.89x10^{-4}	2.41x10^{-8}	2.64x10^{-1}1	0.31	0.125
				1.78x10^{-3}	6.60x10^{-7}	0.00		
20	Root Dry Mass	100% perlite	Semi-mature wood	-1.29x10^{-3}	2.86x10^{-6}	-1.22x10^{-1}0	0.28	0.131
				5.14x10^{-3}	2.02x10^{-6}	0.00		
21	Root Dry Mass	100% perlite	Mature wood	4.05x10^{-4}	-3.89x10^{-7}	9.24x10^{-1}1	0.58	0.005
				2.21x10^{-3}	8.70x10^{-7}	0.00		
22	Root Dry Mass	50% peat /	Softwood	9.92x10^{-5}	5.37x10^{-6}	-2.35x10^{-1}0	0.38	0.071
		50% perlite		8.17x10^{-3}	3.03x10^{-6}	0.00		
23	Root Dry Mass	50% peat /	Semi-mature wood	ns	ns	ns	ns	ns
		50% perlite		ns	ns	ns		
24	Root Dry Mass	50% peat /	Mature wood	ns	ns	ns	ns	ns
		50% perlite		ns	ns	ns		

[x]Coefficient, [y]Standard error of coefficient, [z]ns= no significant regression equation was derived.

Rowe, D.B., F.A. Blazich, and F.C. Wise, 1996. Adventitious rooting of stem cuttings of loblolly pine as influenced by carbohydrate and mineral nutrient content of hedged stock plants. *Comb. Proc. Intl. Plant Prop. Soc*., 46:682-688.

SAS Institute, 1988. SAS User's Guide: Statistics, Ver. 5 (ed). SAS Institute Inc., Cary, NC. p. 955.

Simpson, B.J. 1988. A Field Guide to Texas Trees. Gulf Publ. Co., Houston, TX. p. 372.

Vines, R.A. 1960. Trees, Shrubs, and Woody Vines of the Southwest. Univ. of Texas Press, Austin, TX. p. 1104.

Wasowski, S. and A. Wasowski, 1997. Native Texas Plants. Gulf Publ. Co., Houston, TX. p. 407.

Welsh, D.F., W.C. Welch and R.L. Duble, 1991. Landscape Water Conservation…Xeriscape™. B-1584, Texas Agric. Ext. Ser., Texas A&M Univ., College Station, TX. p. 12